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PRELIMINARY PROBLEMS IN THE DESIGN OF MANUFACTURING BUILDINGS.*

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The actual design of a manufacturing building, as a structure which is to be built of certain materials, to carry given loads, does not, as a rule, present any engineering difficulties which cannot be satisfactorily solved by the usual methods given in books that treat on this subject. It resolves itself simply into the problem of ascertaining, as nearly as possible, the stresses which the loads produce, and of proportioning the materials to take care of these stresses. The *Preliminarv Problems* however, which fix the nature of the building, its size, shape, arrangement, the materials to be used, and the loads to be provided for, all form an immensely broader subject, extending beyond the bounds usually set for the engineer, and touching the very heart of the world of Business and Manufacturing.

These preliminary problems bear the same relation to the detail design that the work of the locating engineer on a new railroad bears to the work of the man who stakes out the line, only in the case of manufacturing buildings they are more complexed. In the following discussion, the writer will endeavor to show how exceedingly complex the designing of a manufacturers' building may be, and the relation of the engineer to this only partially developed field of work. Older members of the Engineering Society will probably find little in it of interest or profit, for it is written for the purpose of stimulating the minds of the younger members by suggesting lines of thought which will tend to broaden their ideas of the profession they have chosen.

Before one can appreciate the complexity of the problems which the design of manufacturing buildings presents it is necessary that he have a thorough knowledge of building materials and the special use for which they are adapted.

* Read before the University of Toronto Engineering Society, Nov. 1st., 1911

It would take many books to exhaust this subject, and we can here only briefly describe three of the common types of Construction, namely:—

1. Slow burning or mill construction.
2. Fire proof construction.
3. Steel frame construction or mill buildings.

1. Slow Burning Construction.

Slow burning or mill construction is simply a special class of timber work. Such a building will have heavy brick walls with the interior columns, beams and floors of massive timbers so disposed as to present the least possible opportunity for the spread of fire. The columns are made of single timbers, usually square, capped with a corbel or short beam which forms a seat for the column of the next floor above, and supports the cross beams which carry the floor. This corbel may be replaced by a steel or cast iron cap which is more reliable when the loads are great. The cross-beams are also heavy single timbers and on these are laid 2in. by 4in., or 2in. by 6in. pieces set on edge and spiked together so as to form a floor 4in. or 6in. thick, as the case may be. A hardwood wearing floor 1in. thick is usually laid on this. Note the absence of all joist and any thin projecting woodwork which might easily catch fire. In case a fire should start, the thick floors would tend to confine it to one story and the heavy beams and columns would burn slowly, thus giving the fire department a chance to put it out before it destroyed the whole building. This construction is only effective, however, when used intelligently, for unless all the many rules for preventing the spread of fire are carefully observed, the result may be disastrous.

The roof of such a building may be constructed like the floor, or, if the span between the rafters is not too great, matched sheeting may be used. This is covered with a felt and gravel roofing material or some one of a score of special roofings which will resist the attack of fire.

The cost of long timber of large cross section practically limits the length of beams to somewhere between twelve and sixteen feet. This means that in a wide building there will have to be many columns which take up room and interfere with the arrangement of machinery.

2. Fire-proof Construction.

While there might be a difference of opinion as to how far it is expedient to go in making a particular manufacturing building fire-proof, it is well understood that, if a building is to stand all the vicissitudes of a conflagration, it must be made entirely of brick, concrete, terra-cotta, and steel, the steel to be well protected from the direct heat of the fire.

It is in office buildings, hotels and tenement houses that fire-proofing principles have been most extensively applied, and the

manufacturer who requires a building of somewhat similar form will use similar methods of construction, adapting them to his special needs. Re-inforced concrete may be used entirely for floors, beams and columns, or steel may be used for the beams and columns to form a framework to carry the floors. In this case the steel must be covered with at least 1½in. to 2in. concrete.

Terra-cotta is being introduced for use in certain classes of manufacturing buildings, but being more or less brittle and not suitable to withstand vibration and shocks, its use is limited. Its most extensive use is in the form of tile for roofs, where its lightness is an advantage.

3. Steel Frame Buildings.

This class of construction is used for rolling-mills, machine shops, foundries, etc., which are usually classified under the head of Mill Buildings. Its distinctive feature is the steel skeleton which forms a frame to support the roof and side covering. This covering is usually corrugated iron, galvanized and sometimes painted also. When so constructed the building is entirely metal, even the window sash may be made of steel. The result is that it can stand an immense amount of rough usage and, unless filled with inflammable material, is not easily injured by fire, nor is it effected by the elements provided it is regularly painted and properly cared for.

But in a building of this class its function as a protection from the weather is really secondary, its main duty being to sustain cranes, hoists and other machinery. In fact, the structure is a huge machine itself. In its design the same engineering principles are applied which are used in the building of steel bridges. Every possible stress is estimated and provided for. Often the analysis of these stresses is made extremely complicated by special combinations of traveling cranes, bins, machinery and wind pressures, but all must be taken care of if the building is to be rigid and safe.

Each of the above three types of Construction has its own special advantages and they are often combined in various ways to obtain a desired result. The slow-burning construction has the advantage of being cheap in first cost. Until recently it had a further advantage of time in rapid erection, but it is now so difficult to obtain first class lumber and the cost is such that these advantages are lost. The commercial size and length of timbers obtainable also limits the span of beams and the spacing of the columns, as explained above. However, for factory buildings, such as woolen and cotton mills, etc., where the machinery is small and light, this feature is not necessarily objectionable. But the one which weighs heaviest against it is its inflammability. That means, for one thing, high insurance rates and the ever present danger of fire.

The first natural variation made in slow burning construction, is the substitution of steel for beams and columns. This permits longer spans for the beams and heavier loads on both beams and

columns. Steel columns are often put in the outside walls as well. The steel work is then self-supporting and may be erected complete independently of other trades. As these columns relieve the walls of all beam loads, and also re-inforce it, the walls may be made much lighter than would otherwise be permissible. As a fire risk, however, this combination is considered inferior to the slow burning construction. Steel becomes soft at a red heat and is entirely unable to resist stresses. If, when thus heated, a stream of water is directed on it, it warps and twists. While an ordinary fire will not actually destroy the metal, the physical state of the material may be so altered as to be entirely unreliable. Consequently its salvage value is only what it will bring as "scrap."

In buildings of three or four stories, round cast iron columns are sometimes substituted for the rolled steel. If neatly cast, they present a better appearance than the built-up steel column, but unless designed by one accustomed to working with cast iron and unless they are most rigidly inspected, there is always a very great uncertainty as to their strength. Apart from this unsatisfactory feature, cast iron has the advantage over steel in being better able to resist heat. They will usually cost more than the steel column.

If, in buildings where steel is used, it is protected by about two inches of concrete, practically all the risk of damage from fire is eliminated. This is rarely if ever done if the floors are of wood, for if the fire-proofing is carried to this extent, is only means one step more to make the building entirely fire-proof. Wood floors, however, have this advantage in addition to being cheaper. It is much easier to cut openings or bore holes in them than it is in concrete, and that is an item worth considering where there is likely to be much of this work to do.

As stated above, buildings which are to be fire-proof must be constructed entirely of re-inforced concrete, or steel covered with concrete or terra-cotta. Buildings of this type have come through conflagrations and earthquakes with credit. The one thing to remember in using re-inforced concrete is that there must be no slighting of the work whatever. To get a good job, it is sometimes a continual fight against ignorance and carelessness, and sometimes dishonesty. A mistake once made is very hard to remedy. A defect may easily escape notice until a catastrophe occurs. Many accidents have already been recorded and there have probably been many more that have never reached the ears of the public. There are large new buildings which stand finished, but vacant, and condemned.

That this blot against re-inforced concrete is not fair to this construction, is proved by the fact that many engineers, especially European engineers, get quite satisfactory results although they use much higher unit stresses than the average. The secret is that they take more time for the work, and give it more rigid supervision.

By using a steel frame work for a building, much of the uncertainty as to its safety may be done away with. There is also a saving of head room and floor space, as the steel beams and columns are

smaller than those of re-inforced concrete. In a building of many stories a few inches to each story adds up to quite an item. The columns in the lower stories become so large that, as one writer has put it, the building resembles the Egyptian pyramids—most of the room is on the outside. Nor are engineers agreed as to how concrete sets when poured wet in large masses.

There are other objections to the use of re-inforced concrete for certain classes of manufacturer's buildings. Where it is necessary to make frequent changes, alterations and repairs and in fact in any structure that is not intended to be permanent for many years, it becomes very costly. When it has outlived its usefulness, it is expensive to remove and the materials have little or no value.

Referring to steel frame mill buildings, structural steel has other useful properties in addition to those referred to above. Such a building is not limited to any size, shape or form within reason. Any loads can be taken care of with certainty. The erection of the frame usually goes ahead very rapidly, forming a scaffold for other work. Steel must, however, be frequently painted if exposed to moisture or corrosive gases to prevent rust and coercion.

This brief description of the three classes of manufacturers buildings will give an idea of the principal materials at the disposal of the designer and the special properties of each. In addition to these, there are innumerable patented building supplies of all varieties and grades from which the designer may choose those best adapted to his needs or taste, and the amount of the money appropriated for the work. With all this data at his finger tips, he is in a position to consider the preliminary problems relating to the design of any particular plant. These problems may be discussed under three heads.

1. The problems of utility.
2. The problems of location.
3. The problems of finance.

But while the discussion may be thus separated, in an actual case, the problems are so interdependent that they must be weighed, one against the other, in order to attain the highest possible efficiency. Efficiency in this case means the greatest ultimate value for every dollar expended.

Some of these problems can be handled by means of mathematics, with precision. Some can be settled by the obtaining of definite data. The facts once known, the question is settled beyond discussion. Some conclusions are reached instinctively, or through natural habit without conscious thought. But by far the larger part is a matter of judgment and the more highly this faculty is developed in the designer, the greater his knowledge, the wider his experience, the more accurate will be the solution.

Problems of Utility.

The use to which the building is to be put, will of course, largely determine the general type of design. In many lines of manufacture the building is virtually a tool or machine and as such it should have the same careful attention of an expert as is given to any part of the equipment. Many a plant with the latest and most expensive machinery is handicapped for all time by the poor design of the building that contains it.

Plants for the manufacture of similar products will probably resemble each other but need not necessarily be alike, for different methods, different ideas or special conditions may mean an entirely different lay-out. Fortunately the designer is not usually called upon to design the process of manufacture but it is essential that he have a thorough understanding of the routine through which the materials have to pass.

The amount of floor space, head room, light, ventilation, etc., that each process will require must be decided upon. The question of light receives a great deal more attention these days than formerly, and the effect on the design is quite marked. The different rooms or buildings must be so arranged that the materials may pass from one to the next with the minimum amount of handling or transportation. Provision must be made for the receiving of raw materials and for the shipping of the finished product. Necessary store rooms must be provided at convenient locations. The power plant should be so located as to make the distribution of power convenient and economical. The same rule applies to the heating and lighting plants and water-works system, and all this must be done with an eye to the health, convenience and safety of the employes.

The method and order of erection must always be kept in mind. The cost of putting certain materials in place may be greatly increased unless the work can be done in a certain order, or at a particular time.

Problems of Location.

The actual location of a manufacturing building is usually determined by the owner from business consideration with which the designer has nothing to do, but the site once fixed, the effect on the design of the building or plant is far reaching.

For every line of manufacturing there is an ideal lay-out, but to realize it one would have to have an ideal site, ideal facilities for obtaining power, labor materials and transportation, an ideal climate, and an ideal balance in the bank. Since such conditions are seldom if ever obtainable, it becomes the designer's aim to adapt his design to the special conditions and circumstances, and make the best use of what he has.

The nature of the climate where the building is to be erected must be taken into consideration. The extremes of heat and cold, the violence of storms, the possibility of cyclones and earthquakes,

the maximum snow fall the roof will have to sustain, the depth of the first line for foundations, etc., are some of the questions that depend on the climate. If the plant is to be operated throughout the winter in a northern locality, the problem of heating becomes an important item. As a rule it is poor economy to put up a cold building and then install an expensive heating system to keep it warm. Apart from the mistakes made in this particular, nearly all the other questions will be taken care of by following local customs which have been found to give the most satisfactory results after long years of trial.

The locality in which the building site is situated also has a very important bearing in the design. The very nature of the building will depend upon the facilities for obtaining building materials and their cost. The conveniences for transportation and handling heavy girdles, etc., must often be considered. The designer must not only have a knowledge of the cost of brick, lumber, cement, stone, steel, terra-cotta, etc., at the place where they are produced, but must know the nearest source of his supply, the transportation charges, duty, etc., and the cost of labor required for placing the materials in the building. These latter considerations often prohibit the use of what would otherwise be economical and desirable construction.

Government restrictions and regulations for the health and safety of the employees and the protection of the public must be carefully observed. If the site is in a large city, the building laws will probably place further restriction upon the designer and give him something to puzzle over in his spare moments. In addition to this, there are usually many special by-laws relating to smoke, noise or other nuisances. In order to obtain reasonable insurance rates the rules of the Fire Underwriters must be carefully followed. Labor conditions must be studied, not only in their relation to the cost of the work, but there are places where the Unions can dictate what the nature of the building is to be.

The size, shape and position of the lot will practically determine the proportions and arrangement of building or buildings. In some cases the position of railway switches and the like control the general lay-out. The proximity of high buildings may make impossible the natural method of lighting and change the orientation.

The probability of future extension must be taken into consideration from the start and a general scheme sketched up for as far ahead as possible. A good plan is to build the plant in units so that the addition of a unit to each department will maintain the proper proportions of the whole plant. The installation of one machine in one department may require the addition of a whole wing, to the building, to take care of the corresponding increase in another department.

In this case, provision should be made for as many wings in proportion to the space provided for such machines. However, it is not always possible to apply this system. For example, in a plant where there are to be many electric motors (and the number is likely

to increase), it would show great lack of foresight if the transmission system were so designed that it were necessary to re-wire the plant and put in larger distribution mains every time another motor was added to the equipment. Here is an instance where it would be true economy to anticipate the greatest capacity that would ever likely be required and provide for it at the start. Now the building itself is usually a construction to which this rule applies. Not only should a reasonable amount of room be provided for future needs, but it is even more important that the probability of any increase in floor loads or the capacity of cranes, etc., be taken into account, at the start. It is usually very unsatisfactory, and always expensive, to try and strengthen a building for loads greater than originally planned for, even though the type of construction will permit it. No one who has not had to face such a problem and be responsible for the results, can appreciate what it means, besides, it is exceedingly aggravating to the owner to find a scheme of extension blocked or crippled just through the lack of a little foresight in making the original lay-out.

The Problems of Finance.

The questions of finance which the designer has to consider usually have nothing to do with the securing of the money necessary to carry out the work. But the problem which he does have to keep in mind always is how to get the utmost efficiency from every dollar invested. This means more than merely saving money in the construction. "Savings never pay dividends." It means even more than getting good value for the money spent, for every dollar invested is just one more on which must be paid interest, taxes, etc., if the enterprise is to be a success. If instead of putting the dollar into unnecessary expensive construction or some inappropriate ornamentation, it is so used that it will save something in the cost of maintaining or operating the plant, this means increase in profits. The dollar so invested is helping to earn dividends and is not dead capital.

Thus all the financial problems to be considered here center around the principle of the ultimate value. Will it pay in the long run? But until an infallible rule can be discovered to answer this question, it will be necessary after using every device of mathematics and human wits to still trust to Providence for the results.

The success or failure of an investment depends on the rate of interest received from it and time it has to run. In the case of a building these terms mean the amount of service got out of it, its life or period of usefulness, and its final or "scrap" value. Just what constitutes economical construction for a particular building will depend upon the values given to these conditions.

As an illustration of extreme conditions, take the temporary grand-stand for a football match, and a ten story office building. For the former, which is to be used for a few hours only, the very cheapest type of construction is economical, while for the latter,

whose period of usefulness will be fifty years or more, only the most permanent construction in spite of the greater cost, will pay.

Where the answer to this question with reference to some particular building is not so obvious, it is necessary to assume a certain number of years for the period of usefulness and fix on a sum which will fairly represent its value at the end of that period. From these figures it is possible to determine the per cent. which the value of the building decreases annually. For example, if the original cost of the building is $10,000 and it is estimated that at the end of twenty years its value will be about $3585, it can be shown that the annual decrease in the value is nearly 5%. This decrease is called "depreciation," and if the books of the owner are kept correctly, it will be taken care of in one of three different ways.

1. The value of the building as an asset will be decreased 5% every year. This is an approximate method and is only correct for the twentieth year.

2. A sufficient sum of money will be put aside each year and invested as a sinking fund so that at the end of twenty years it will amount to the total depreciation, in the above case, $6,415. The amount of the sinking fund at any time gives the depreciation of the building to date.

3. A certain sum will be spent annually in repairs so that at the end of the period the building will still be worth its original cost, $10,000.

Assuming that it is possible to get 5% per annum interest on money, the amount necessary to deposit in the sinking fund every year would be $194 (all problems of this nature are solved by the regular rules for annuities—a very interesting and profitable study for anyone having to do with long time investments).

This same amount, $194, represents the average sum which will have to be spent in repair to keep the building at a constant value by the third method. If to this we add the interest on the investment, 5% on $10,000=$500, we have $694, which is the actual amount the owner is paying each year for the building apart from such charges as taxes, insurance, etc.

Suppose a cheaper construction were used, so as to save $2,000 in the cost of the building, but that as a consequence the depreciation amounted to 10% per annum instead of 5%. Then the value of the building at the end of 20 years would be $973. The sinking fund would be $212.44, and the annual cost of the building, 5% on $8,000=$400. $400 plus 212 equals $612. This means an annual saving of $82 by using the cheaper construction which in 20 years would amount to $2,712—the ultimate saving to the owner, not counting the $2,000 saved in first cost.

In the above example the building has been considered simply as an investment, but a far more important consideration in a manufacturing building is its relation to the process of manufacture. Methods are constantly changing, requiring corresponding changes in the building long before it is worn out. In this sense again a manufacturers' building is like a machine—its period of usefulness

is not always measured by its durability. Some little invention or change in process sends it to the scrap-heap. It may be just as good as new but it is worthless.

This relationship is so important in some lines of manufacturing that the method of considering the building as an investment as above is not worth bothering about except for purposes of bookkeeping. The only question asked is, will it reduce the cost of manufacturing sufficiently to pay for itself in a reasonable time?

Now the financial problems of manufacturing usually involve amounts of much greater magnitude than have to be considered in the building or plant. It is quite possible that $100,000 worth of goods could be turned out annually in a $10,000 building. Hence the great importance of the relation of the building to process of manufacture. In this case if 1% could be saved in the cost of the goods produced by increasing the cost of the building 10% it would pay for itself in one year.

If in a plant employing 100 men it were possible by cutting a door in a wall, by changing the location of a machine, by taking out an obstructing column or by some other device, to save 6-10 of a second of each man's time per minute or 6 minutes a day, it would mean that 99 men could then do the work which formerly required 100. If the average rate of wages were 20 cents per hour, it would save $600 a year. It can be shown that if the owner were to borrow $2,600 at 5% to make this alteration, it would pay for itself in 5 years.

But it may be that through faulty design in the first place, it is not possible to make this change, and as a result of this, the owner is losing $600 a year which in 20 years would amount to $19,846.

Many a manufacturer is losing this $19,846 and much more through carelessness in the design of his plant.

It may be noted here that saving in time in manufacturing is a double saving. Not only is there a saving in workmen's wages, but the capacity of the plant is increased as more work can be turned out in a given period. The profit on this extra work must be credited to the change which makes it possible. In addition to this, time in delivery is often a very important factor in securing a contract, and in such cases higher prices may be obtained.

The above discussion is an illustration of what is called Efficiency Engineering or Scientific Management as applied to buildings, a subject that is attracting a great deal of attention just at present. So fine are some engineers' figuring that it has been suggested that even the time which the manager of a concern spends in looking after and ordering repairs to a building be capitalized and added to the ultimate cost.

Usually, however, more weighty reasons make it unnecessary to go to such refinement. In any new venture, which has a struggle before it with a possibility of failure, the first cost must be kept down to the lowest possible figure even at the sacrifice of efficiency, and questions of future growth, may, within reason, be left to take care of themselves. While it is true many a manager to-day bewails his lack of foresight in not preparing for the rapid growth of his

business, still it is better that conditions are as they are than that his business had been wrecked at the start by an overload of debt.

This brief statement of the preliminary problems in the design of manufacturers' buildings should make clear at least one fact, and that is that the final plan must be a compromise—a compromise between the "possible" and the "expedient,"—between the "ideal" and the "practicable." In the completed building there may be many things that at first glance look like blunders, but a deeper investigation will show a carefully thought out purpose.

A good definition of an ideal building is given by Mr. Charles Day in his book "Industrial Plants." He says: It must so conform with all the industrial requirements that "the work of manufacturing may go forward with practically as much freedom as though the building did not exist at all. That is, the workers, whether employed at individual machines or engaged in moving material from point to point, should, to all intents and purposes, be unconscious of the existence of the housing structure." The building that will answer all requirements thus efficiently for the least cost—the period of use being considered—will be the best solution of the problem.

This discussion should also bring out the fact that the design of manufacturing buildings is more of an engineering than an architectural work. It will have been noticed that throughout this paper the name "designer" has been used and not "architect" or "engineer." The reason is that neither of these names, used in their usual sense, gives a correct idea of this branch of the profession. A new term has come into use and we know have the "Industrial Engineer."

The average architect is not only entirely incompetent to handle these problems but all his training quite unfits him for this class of work. The ordinary rules of architecture are too narrow to be applied to what is virtually a machine. Besides, in a large number of cases the questions of architecture never enter at all. There are many examples of handsome but inefficient manufacturing buildings. On the other hand there is a great deal of justice in the charge that works designed by the Engineer are unnecessarily hideous, and the Industrial Engineer cannot consider himself properly qualified if he has not a knowledge of the ordinary rules of architecture and aesthetics as applied to buildings.

But, as shown above, the work of the Industrial Engineer requires more than a knowledge of Architecture and Structural Engineering. He must have at least a general knowledge of Applied Science in all its branches in order to be able to grasp the salient features of any part of the manufacturers' installation, or his process of manufacture. It is not to be expected that he should be able to advise his client in his own business of manufacturing but he will often find that his clients' ideas of what he wants are limited by his lack of knowledge as to what is practicable. Here the engineer can be of assistance. It must be admitted, however, that more often the engineer will have reason to feel extremely flattered by his clients' faith in his ability to accomplish the impossible.

In addition to his professional training, the industrial engineer must have a broad mind, free from narrow prejudices, to be able to appreciate the good points in special materials and constructions. He must have sound judgment and a fair talent for prophecy to build for the future. He must be a wide-awake, up-to-date business man with more than enough ability to handle the details of his own work for the financial problems referred to above require a business acumen not usually expected of an engineer.

After all the preliminary problems in connection with some particular building have been threshed out, the actual work on the design and construction can begin. If the engineer has complete charge of the work, then follows in natural order the making of the general plans and specifications, the calling for tenders, selecting reliable contractors and awarding the contracts, the laying out the lines of the work, the fixing of levels, the checking and approving detail drawings, the inspection of materials and work, the ordering and installing of and putting in operation the equipment and the thousand and one details which have to be attended to in order that the work may be done in an orderly, expeditious and systematic way and be brought to a satisfactory and successful conclusion.

But these problems have to do with the actual design and construction and are beyond the scope of this paper.

MR. LEONARD'S APPOINTMENT.

R. W. Leonard, C.E., has recently been appointed successor to Hon. S. N. Parent, as chairman of the National Transcontinental Railway Commission. Mr. Leonard needs no introduction to engineers, and more especially to "School" men. "The Scope of Engineering in Canada" was the subject of an address delivered by him to the Engineering Society and published in the November, 1910, issue of this journal. He is also known as an active member of the Board of Governors of the University of Toronto. More particularly as an engineer after his own definition of the term has he formed his acquaintance, and his recent appointment to the Commission denotes a lofty recognition of his ability and qualifications as a member of the profession.

Among the recent staff appointments are the following:—Mr. P. Gillespie, Associate Professor of Applied Mechanics; Mr. H. W. Price, Associate Professor of Electrical Engineering; Mr. G. R. Anderson, Associate Professor of Physics; Messrs. L. M. Arkley and L. B. Taylor, lecturers in Mechanical Engineering. Newly appointed demonstrators are:—in Electrical Engineering, T. H. Crosby, '09; Mechanical Engineering, A. W. Youell, '10, and F. S. Milligan, '10; Architecture, C. R. Redfern, '09, and L. T. Rutledge, '09.

CENTRALIZATION OF HEAT, LIGHT AND POWER FOR THE UNIVERSITY OF TORONTO.

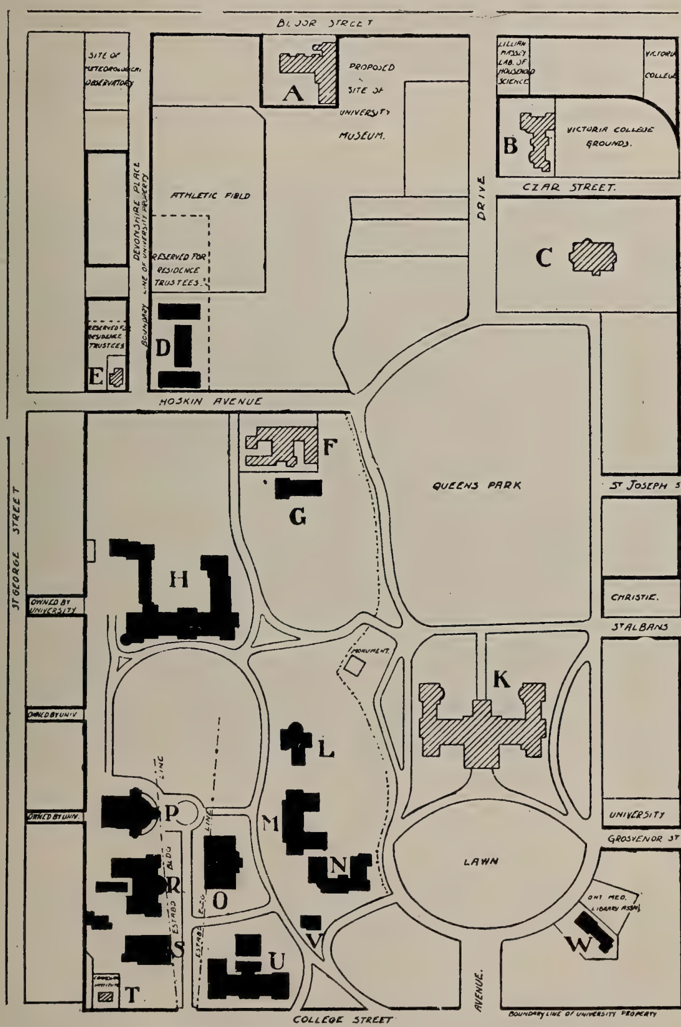
J. C. Murton.

The University of Toronto and its affiliated colleges embrace some twenty-four buildings located between College Street and Bloor Street West. The recent installation by the Board of Governors of the central plant for supplying heat, light and power to these buildings involved many difficulties attendant upon connecting the large number of buildings, all heated and lighted by different systems and from different sources. The erection of the central station near the centre of the distributing system being inconsistent with aesthetic conditions, it was deemed expedient to choose a location in the ravine between the Medical Building and the Provincial Government Buildings. In order to obscure the view of the power house from the Parliament Buildings, considerable excavation had to be done and the station is practically constructed seven-eighths below ground. The smoke-stack is some distance from the power house and is connected to it by an underground flue. This stack is so located that the addition of a proposed wing to the Medical Building will completely enclose it. In this way the power house is very effectively concealed from the view of Queen's Park.

The old method of heating the individual buildings was by separate boilers located in the basements. All of the buildings with the following exceptions used electric current from the city service: the Mining Building contained two Heine boilers and a 150 k.w. Leonard engine and generator. An emergency connection with the city service was also installed. A switchboard in this building controlled the light and power supply for the Milling, Thermodynamic and Engineering Buildings. The Milling Building was also heated from the boilers in the Mining Building. Both the Physics Building and Convocation Hall were heated and lighted from a small plant contained in a power house located in the rear of the Physics Building. This power house contained two Babcock & Wilcox boilers, a 50 k.w. and a 100 k.w. Robb-Armstrong engine direct-connected to Westinghouse generators. There was also a motor generator set for breakdown service. This power house is now dismantled and the units re-located as noted further. Convocation Hall is connected to the Physics Building by a tunnel through which the various mains are run. The main University building, known as University College, contained four horizontal tubular boilers used for heating and power. Current was generated with a small unit and light and heat supplied to the main building and to the Observatory. Connection to the Observatory is made through a tile conduit. Current was also furnished from this same source to the University residences (three buildings) and to the presi-

EXTERNAL VIEW OF CENTRAL STATION, THE GREATER PORTION OF WHICH IS BELOW GROUND.

dent's house on St. George Street. The three residence buildings are connected by underground passages, through which the mains are carried. The electric cables are carried to the Middle or East Residence, and current is



GENERAL PLAN OF UNIVERSITY GROUNDS

distributed from here to the North and South Residences. The University Museum is now under construction, a small portion of it being already occupied. As the central plant was contemplated at the time this building was started, no provision

for obtaining heat and light other than by the central plant was made. The Victoria University group will also be heated and lighted by the University's central plant. There are four buildings in this group. Victoria University main building has been overhauled during the past summer, and fitted up for connection to the central plant. This building was previously lighted by gas, although wired for electricity. A hot air system of heating, embracing several small furnaces, was in operation. The building has been equipped with a modulation system of steam heating and has been re-wired. Burwash Hall, the men's residence, is at present under construction. This building and

INTERIOR OF ENGINE ROOM SHOWING GENERATORS AND STEAM MAINS

the adjoining dining hall, however, are depending on connection to the central plant, and no provision is being made for connection to the city mains, or for the installation of boilers.

Power House.

The power house, as mentioned before, is sunk almost completely in the ground. The building is divided into two parts, boiler-room and engine-room. The boiler-room contains four Babcock and Wilcox boilers, rated at 450 boiler horse-power each. Room is provided for the addition of two similar units, should this be necessary. Coal storage is provided east of and above the boilers. Coal is delivered by an inclined roadway

to the roof of the power house, where a ten-ton wagon scale is provided. Coal is dumped into the storage bin, and falls by gravity into the boiler-room through two hopper scales. An electric hoist is provided in one corner of the boiler-room for removal of ashes, and delivery of supplies.

Draft for the boilers is obtained by two multivane fans driven by direct connected engines. The stack is not of sufficient height to provide natural draft for the kind of coal which is being burned. The breeching and fan connections are so laid out that should the fans be shut down for any reason, the flue gases have a straight run to the stack. Feed water is supplied to the boilers by three duplex plunger pumps. These

INTERIOR OF BOILER ROOM, SHOWING BREECHING AND FAN CONNECTIONS

pumps obtain their supply from the feed water heater in the engine room, and from two separate connections from the city water service.

The engine-room is equipped with two Robb engines, which were taken from the old Physics power house. A five-ton crane runs the entire length of the engine-room. This crane was also brought over from the old Physics power house. The Leonard engine and generator formerly used in the Mining Building are also installed here temporarily. This unit will be replaced by a new compound high-speed engine now under construction.

The main piece of apparatus in the engine-room is the 300 k.w. Curtis turbo-generator, which is at present carrying the

total load of the plant. The generator for this unit is wound for 120-240 volt three-wire operation. The Robb engine units are each two-wire 120-volt machines, one being a 50 k.w. and the other a 100 k.w. unit.

The main steam header is carried on the east wall of the engine-room. This header supplies an auxiliary header on the other side of the wall in the boiler-room, which supplies the boiler feed pumps, injectors and fan engines.

The exhaust connections from the engines are carried in a trench to the muffler tank and grease extractor. From here the exhaust is carried to a tee in the main exhaust header. One outlet from this tee is connected to the vertical discharge pipe leading to the exhaust head, and the other outlet connects to

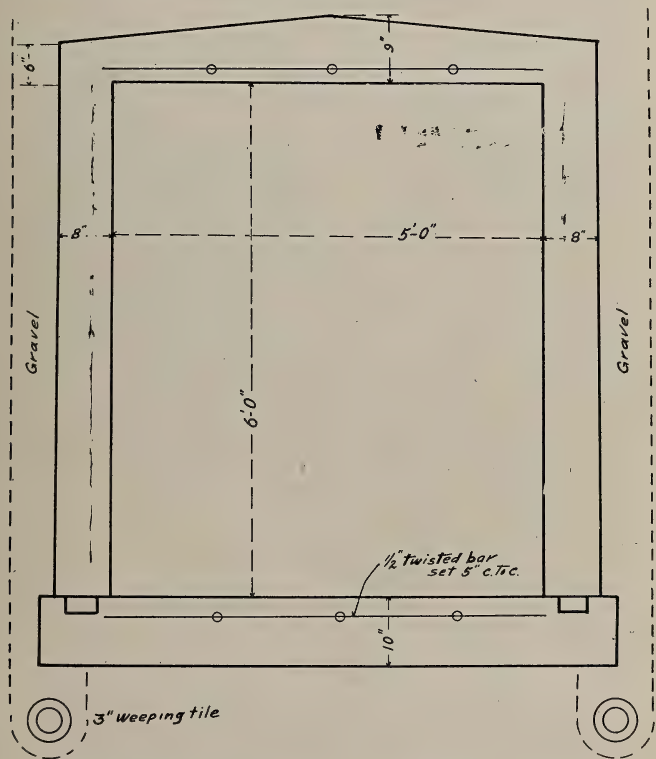
EXCAVATION FOR 6 x 6 TUNNEL, FROM POWER HOUSE TO MEDICAL BUILDING

the exhaust line leading to the main heating line in the tunnel. The exhaust line is fitted with a back pressure valve which controls the pressure on the heating mains. The exhaust from the turbine is carried separately to the exhaust header. It was intended at one time to install a distilled water system for all the buildings on the plant, using steam from the turbine for this purpose. Connection is made from the main exhaust header to the feed water heater.

The condensation returns from the steam heating system are collected in a large receiving tank, and are pumped from this tank to the feed water heater, and from there are pumped directly to the boilers.

The drips from the engines and turbine are taken care of by two main traps in the boiler room. The high pressure drips

from the main header and steam separators are carried to a receiving tank, from which they are discharged to the feed water heater through a trap. The low pressure and exhaust drips, and all drips from the fan engines and pumps are carried to a receiving tank in the sump pit, from which they are lifted by a trap into the blow-off tank. A duplex pump is provided in the sump pit to take care of these drips in case of any accident to the lifting trap. A small motor-driven centrifugal pump is installed to lift the water from the sump pit to the sewer.



CROSS SECTIONS OF MAIN BRANCH TUNNELS

The switchboard is located along the west wall of the engine room. It consists of eight panels, four being generator panels, one a meter panel, and three feeder panels.

The turbine and the new 300 k.w. unit now under construction will be connected so as to carry the entire load of the plant. The two Robb engine units are connected to operate in parallel with the other units. These engines are two-wire machines, but connections have been made so that they will operate together as a three-wire unit. Special busses have been provided so that the electrical energy for experimental work in Engineering build-

ing can be supplied by these units if required. The electric furnaces in the Mining Building form part of the general load of the plant, but they may be connected directly to the Robb units by manipulating a double pole double throw switch.

Tunnels.

A system of tunnels connects all the buildings on the plant. These tunnels are constructed of concrete, with the roof and bottom reinforced as is shown in the accompanying figure. The main tunnel leaving the power house is 6 ft. x 6 ft. inside. The branch tunnels are 5 ft. x 6 ft. inside, and the service tunnels to

EXCAVATION SOUTH OF THE ENGINEERING BUILDING, DONE IN 10 FT. SECTIONS OWING TO PROXIMITY OF FOOTINGS

each building are 3½ ft. x 4 ft. inside. The tunnels are drained from the inside by direct connection to the city sewer system through water seals and checks. Drainage from the outside is taken care of by weeping tiles running the entire length of the tunnels on both sides, and connecting to the city drainage system at various points.

The floor of the tunnels is uniformly 10 inches thick. The sides are 8 inches thick, and the roof 6 inches thick at the sides, with a 9-inch crown in the centre.

Starting from the power house, the main 6 ft. x 6 ft. tunnel runs to the Medical Building. Half-way over, a 3½ ft. x 4 ft.

connection is made to the Biological Building. From the west side of the Medical Building the tunnel runs 6 ft. x 6 ft. for about twenty feet, and then branches north and south by means of two 5 ft. x 6 ft. tunnels. The branch going south runs to the north-east corner of the Thermodynamics Building, where a branch is run west to the Physics Building. A 3½ ft. x 4 ft. branch is run from this Physics tunnel to the Engineering Building. There

EXCAVATION ALONG AVENUE ROAD FOR DOMESTIC SCIENCE SERVICE

was already in existence a tunnel between the Physics Building, the Physics power house, and Convocation Hall, and this tunnel was used in connection with the new plant. A new 3½ ft. x 4 ft. branch tunnel was run from the Physics Building to the Chemistry Building.

Going back to the north-east corner of the Thermodynamics Building, the other branch runs into the boiler-room of the

Thermodynamics Building. A $3\frac{1}{2}$ ft. x 4 ft. tunnel is run from the Thermodynamics Building to the Mining Building. The Milling Building is connected to the Mining Building by underground tile conduit, in which the steam, water, and gas pipes and the electric cables are carried.

The 5 ft. x 6 ft. tunnel branching north from the junction in front of the Medical Building runs directly north to a point a few feet beyond Hoskin Avenue, with $3\frac{1}{2}$ ft. x 4 ft. service

FORMS READY FOR CONCRETE

tunnels to the Library, Main Building, Gymnasium, Wycliffe College, and the three University residences. The Observatory is connected to the 5 ft. x 6 ft. tunnel by tile conduit.

From Hoskin Avenue, the tunnel runs to the new University Museum. This building was constructed with a tunnel through the basement to which the main 5 ft. x 6 ft. tunnel connects. On the east side of the Museum the 5 ft. x 6 ft. tunnel continues across Avenue Road to a point opposite Annesley Hall,

from which point, branches run north and south to the various buildings belonging to Victoria College. The north branch runs 5 ft. x 6 ft. to a point from which the 3½ ft. x 4 ft. service to Annesley Hall is taken off. From this same junction the tunnel continues north 3½ ft. x 4 ft. to the School of Household Science.

The south branch of the 5 ft. x 6 ft. tunnel runs to Victoria Library. The cables and heating mains are carried overhead in the basement of this building, and a 5 ft. x 6 ft. tunnel is run from the east side of the Library to Burwash Hall residences. A 3½ ft. x 4 ft. service is taken from this tunnel to Victoria College main building, and a 3½ ft. x 4 ft. service tunnel is also run to Burwash dining hall.

Entrance to the tunnel is possible through the various buildings and through manholes located at all tunnel junction points. These manholes are thirty-three inches in diameter and have inner and outer covers. At four main points, extra large manholes, 4 ft. 6 in. in diameter are provided, so that long lengths of pipe may be inserted or removed from the tunnels. Between the Library and the Main Building, where the contour of the ground made it permissible, a sloping manhole has been set. The curb and cover to this manhole are almost vertical.

The tunnels are lighted by electric bulbs located every 125 feet, and run on a separate lighting circuit from the power house.

Electrical Distributing System.

The electrical distributing system is carried in these tunnels. The Edison three-wire system is used. Those buildings which were wired for two-wire operation were changed over to operate on a three-wire system.

New panel boards and switchboards were provided in various buildings. The distributing switchboard in the old Physics power house was moved into the Physics Building, and wired to control the current to the Physics Building, Convocation Hall and the Chemistry Building. This switchboard contains three panels which control the heating system by means of compressed air, and one panel which controls the ventilating system. New controlling panels were provided for the Main Building and for Victoria Library.

There are thirty-one cables leaving the power house varying in size from No. 6 to 1,250,000 c.m. It might be mentioned here that considerable delay was caused in the manufacture of these cables on account of their enormous size, nothing to compare with them in size having been previously ordered in Canada. Three cables supply the Biological Building, three supply the Medical Building, five cables are run to the Mining Building, which also supplies the Milling and Thermodynamics Buildings. The Engineering Building is supplied by cables tapped onto the Mining Building feeders at the tunnel junction in front of the Thermodynamics Building. There is also a special cable run

from the power house to the Engineering Building, as well as two special control wires, to be used in connection with the Electrical Engineering experimental laboratory work. Two special cables are also run to the Mining Building to supply the electric furnaces. Three feeders run to the Physics Building, which in

UPPER: METHOD OF CONSTRUCTION, WHERE NO EXCAVATION WAS NECESSARY

LOWER: VIEW OF 400 FT. RUN OF COMPLETED TUNNEL FROM MUSEUM EAST

turn supplies Convocation Hall and the Chemistry Building. Three cables run to the Library and three to the Main Building. The new control panel in the Main Building controls the supply

of current to the University Gymnasium and to Wycliffe College. Three cables run to the University Museum, and five to the Victoria group. Electrical connections are made to the University residences at the tunnel junction just north of Hoskin Avenue. The cables running to the University Museum and to the Victoria group are tapped, and cables run from these taps to the distributing panel in the Middle or East Residence. A panel in the Museum controls the supply to the Museum itself and also to the School of Household Science. Cables are run from the Museum direct to this building. A switchboard in Victoria Library controls the current supply to Annesley Hall, Victoria College Main Building, and to Burwash residences and dining hall.

CABLES AND PIPING, STEPPING FROM LOWER TO HIGHER ELEVATION IN MEDICAL BUILDING

The cables are carried on porcelain cleats fastened by lag screws to 2 in. x 4 in. wooden uprights bolted into the tunnel walls, 4 ft. 6 in. centre to centre. These vertical wooden supports were treated with a preservative compound before being mounted.

With a few exceptions, the cables are carried in the tunnels exclusively. Connection is made from the Engineering Building to the tunnel by tile conduit. Connection is also made from the service tunnel to the University residences through the old tile conduit formerly used to carry the cables from the Main Building to the residences.

Each generator is protected by Canadian General Electric circuit breakers. The turbo-generator is designed for 50 per cent. overload for two hours. All voltage losses or drop are calculated to be not more than 2 per cent. All switchboards are provided with Bergman recording watt-meters for calculating amount of current consumed in each individual building. On the main switchboard are located a totalizing curve-drawing ammeter and Thomson direct reading station watt-meters for each unit. All circuits on these have the usual enclosed fuse protection.

The quantity of current consumed is approximately 1,600 amperes at a pressure of 240 volts.

Heating System.

The heating system presented quite a problem, due to the different levels of the buildings and the fact that several buildings had different levels in themselves. The level of the Medical Building, being the most central, was taken as the low point of the system. All buildings whose levels were above that of the Medical Building return the condensation from the heating system by gravity.

Several buildings, however, were below the Medical Building level. These were treated as shown in the following paragraphs.

The following four points in the system were selected, and at these points gravity tanks were installed, all at the same level: one in the South Residence, one in the Main Building, one in the Physics Building, and the fourth in the Mining Building.

The condensation from Victoria University main building will be run to a pump and receiver located in the basement of the building. These returns will be pumped to a receiving tank in Burwash residences. The returns from Burwash residences and dining hall will drain to this receiving tank, and from there will be pumped to a receiving tank in the University Museum. The returns from the School of Household Science, Annesley Hall, and Victoria Library, will all drain by gravity to a tank in the University Museum. The water from these tanks will then be pumped from the University Museum to the above mentioned "gravity tank" in the South Residence. This tank then discharges by gravity into the main return line of the system.

The University residences, Wycliffe College, the Gymnasium and the Observatory all drain by gravity to the main return. The Main Building has several different water levels. These are all eliminated, and all returns are collected in a receiver in the boiler pit. From this receiver, they are pumped to the "gravity tank" in this building. This tank discharges by gravity in the same manner as the one in south residence.

The Library, Engineering, Medical and Biological Buildings all drain by gravity into the main return.

The Thermodynamics Building is heated by the exhaust steam from its experimental plant, but connection is made so that steam may be supplied from the central plant in case of a shut down of its own boilers.

The returns from the Milling Building are carried to a receiver in the Mining Building. When the Thermodynamics Building is taking steam from the central plant, the returns from this building will also be collected in the receiver in the Mining

MAIN STEAM LINE, LAID ON CONCRETE FLOOR,
NORTH OF HOSKIN AVE.

Building. These returns are pumped to a "gravity" tank on the second floor, and drain from there to the power house.

The condensation from Convocation Hall, Chemistry Building, and Physics Building is collected in a receiver in the Physics Building and is pumped from there to the third "gravity tank," and drains from this tank to the main return line in a manner similar to the others.

The steam that will be furnished from the exhaust of the turbine, the engines, and other equipment of the power house is not sufficient to supply the entire heating load. Provision, therefore, had to be made to supply live steam from the boilers direct to the system, whenever the pressure in the heating main drops below a certain point. A high pressure "booster" line is also carried in the tunnel, paralleling the supply and return heating mains. This booster line furnishes live steam to all the buildings for hot water heating service, and to certain buildings for steam tables, kitchen cooking apparatus, experimental work, etc. The exhaust steam heating main is also connected inside the buildings through pressure reducing valves to this booster line, as a further precaution to insure plenty of steam for heating.

Valves have been installed and piping connections have been made to all buildings so that steam can be shut off at any time from the central plant, and the buildings heated by their individual boilers.

The steam used for heating is measured by the condensation returned to the system. Each building is provided with a condensation meter which measures all water returned to the system through the building. A meter on the main return line just outside the power house measures the total amount of water returned to the receiving tank in the power house.

All condensation in the booster line is discharged through traps into the main return line. All condensation in the exhaust steam heating line is collected at various points and discharged into the return line through lifting traps.

H. W. Tate, '09, is on survey work for Chas. E. Goad Co., civil engineers, Toronto.

C. G. Titus, '10, is engineer for the Hudson Bay Mines, Cobalt, Ontario.

H. W. Tye, '08, is in the Construction Dept., Canadian Pacific Railway shops, Winnipeg.

M. B. Watson, '10, is resident engineer on sanitary and hydraulic work for Chipman & Power, at Neepawa, Man.

Mr. J. B. Challies, '04, has recently been appointed hydraulic engineer of the railway lands branch of the Department of the Interior.

Mr. R. G. Swan, '09, who has been engaged on water power investigations on the Winnipeg River, has joined the engineering staff of the British Columbia Electric Railway Co. at Vancouver.

Mr. T. H. Hogg, '07, is managing editor of The Canadian Engineer, succeeding Mr. James, '04, in that capacity. Mr. Hogg was previously engaged in the design and construction of the new works of the Ontario Power Company at Niagara Falls. Mr. James, upon severing his connection with editorial work, took up his duties as engineer for the Board of Highway Commissioners, York County, and as engineer for the town of North Toronto.

ELECTROCHEMICAL AND ELECTROMETALLURGICAL DEVELOPMENTS IN CANADA.*

S. DUSHMAN, B.A., Ph.D.

The number of electrochemical plants at present in operation throughout the Dominion of Canada is not very large. The reasons for this state of affairs are not far to seek. Up to the last decade the history of the country has been practically the story of the struggles of pioneers with the difficulties and disappointments which must always confront men in a new land. The toil of the soil, no matter how fertile it may be, is sufficient to engross in itself the attention of a small and scattered community. But the discoveries, made within the last few years, of rich mineral wealth in different parts of the country, and the exploitation by three trans-continental railroads of the vast prairies of the West, have led not only to a phenomenal growth in population but also to an influx of capital from both the United Kingdom and the United States which promises well for the electrochemical future of the country.

In the following paper the discussion of the electrochemical and electrometallurgical developments of Canada has been divided into two parts. The first part contains descriptions, as far as available, of the different electrochemical plants at present in operation, the second part is devoted to a survey of the mineral resources of the country and their possible exploitation by electrochemical methods.

PART I.

We shall begin at the extreme west, in the province of British Columbia. The great Cordilleran ranges, whose peaks often reach as high as 20,000 feet above the sea level, condense enormous masses of snow, which by their annual melting serve to feed many small torrents as they come rushing down to empty into the great rivers of the lower valleys. One such tributary is the Kootenay, whose length is about 350 miles, and which drains an area of 9,800 square miles.[1] At Bonnington Falls, which is situated ten miles below the city of Nelson, the river has a minimum flow of 5,850 cubic feet per second, with a natural drop of about seventy feet. In the months of June and July, when the snow melts, the flow rises as high as 60,000 cubic feet per second. At this point the West Kootenay Power and Light Company has erected two plants, the older one with a capacity of 4,000 H.P., and a later one, in which two 8,000 H.P. turbines are installed. From the latter, power is transmitted at

* Paper presented at the 20th meeting of the American Electrochemical Society, Toronto, Sept. 22, 1911.

(1) Report 24, Department of Mines, Ottawa. The mining and metallurgical industries of Canada (1908) p. 225.

22,000 volts to Rossland and Trail (the latter being twenty-eight miles distant), and at 60,000 volts to Phoenix, at a distance of 79 miles, Grand Forks, 69 miles away and Greenwood which is farthest at 83 miles.[2] "Most of this power is used in mining and smelting work and for the lighting requirements of mining towns." Besides these plants the company operates another plant on the Kettle river, about 12 miles below the town of Grand Forks, where the head of water is 156 feet. The average cost of electric power throughout the area covered by the lines of the West Kootenay Power and Light Company does not exceed one quarter the cost of steam power.[3] The result has been that throughout the whole of the Boundary district, steam power is a thing of the past.

The Trail Lead Refining Plant.

As already mentioned, a large portion of the power from one of the plants is sent to Trail where the Consolidated Mining and Smelting Company of Canada operates a plant for smelting copper and lead ores from its numerous mines. The lead bullion produced by the smelting operation is cast into anodes and refined by the well known electrolytic process of Mr. A. G. Betts.[4] The object in refining the lead is to recover the copper, antimony and bismuth, as well as the gold and silver contained in the bullion. The metal is melted in a large iron tank of 50 tons capacity, and the dross, which forms on the surface, carries away most of the copper, while the fused metal is pumped by an electric centrifugal pump to the anode moulds. The anodes, which contain 97.9 to 98.4 per cent. lead are each 30 inches wide, 31 inches deep, and vary in thickness from 1½ inches at the top to ⅞ inch at the bottom, the wedge-shape being used to facilitate extraction from the mould. Side lugs project at the top to permit suspension from the bus bars into the tank. The weight of each anode is about 400 pounds. There are 22 of these placed on a car and trammed to position alongside the tank. They are then placed in position in the tank by an electric crane, so that one cathode is situated between two anodes.

Each cathode consists of a thin sheet of refined lead, weighing about 20 pounds. The top edge is wrapped around a copper bar for the purpose of suspending across the bus bars. All the cathodes are connected to one of the bus bars running along the top of the tank, while all the anodes are similarly connected to another bus bar.

The tanks are about 6 feet 4 inches long, 2 feet 6 inches wide, and about 3 feet 6 inches deep. They are made of wood bolted together, and coated with tar inside.

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(2) J. N. Pring, Some Electrochemical Centres, p. 51.
(3) Report 24, p. 225.
(4) Literature on Lead Refining at Trail:—
J. N. Pring, Some Electrochemical Centres, p. 53.
A. G. Betts, Lead Refining by Electrolysis.
M. de K. Thompson, Applied Electrochemistry, pp. 64-6.
Report 24, pp. 242-3.

The electrolyte is a solution of lead fluosilicate containing an excess of hydrofluosilicic acid.

Hydrofluoric acid (HF), prepared by treating fluorspar (CaF_2) with sulphuric acid, is allowed to trickle through a layer of broken quartz or pure silica sand thus producing hydrofluosilicic acid. The latter is then neutralised with white lead. As the electrolyte continually tends to dissolve an excess of lead from the electrodes and thus lose its acidity, it is found necessary to add free acid from time to time. The average composition of the electrolyte is stated to be as follows:—

H_2SiF_6	9.5 to 10.5%
Pb (as $PbSiF_6$)	4.5 to 5.2%
Specific gravity	1.13 to 1.16

One of the most remarkable features of the process is the fact, discovered by Mr. Betts, that the addition of a slight amount of glue to the electrolyte leads to the formation of smooth coherent deposits at the cathode.

The usual current density employed is 16 to 18 amperes per square foot, a total current of 3,100 to 3,600 amperes at 70 volts being supplied to two parallel sets of 90 cells. During the electrolysis, lead, iron, zinc and nickel go into solution, but owing to the small amounts of the last three constituents, and the acidity of the bath, only the lead is deposited on the cathodes. The other constituents of the anode metal, such as the precious metals, copper, and antimony, go into the slimes. The average composition of the slimes is as follows:—

Lead, 10 to 18%; Arsenic, 23 to 28%; Antimony, 21 to 27%; Copper, 7 to 22%; Iron, 1 to 2%; Silver, 5%.

After the electrolysis, which is allowed to proceed until about 75 per cent. of the anode is dissolved, the cathodes are washed, melted, and cast into ingots. The slimes are washed and then treated with a solution of sodium sulphide, thus dissolving antimony and arsenic. The solution is electrolysed for the recovery of antimony in cells containing iron cathodes and lead anodes. The antimony deposited on the cathodes is melted under a flux of antimony oxide and sulphide and gives bars of pure metal. The residue from the sodium sulphide treatment containing silver, copper and gold, is dried and roasted, and then boiled with a solution of sulphuric acid which dissolves the copper and silver. The resulting solution goes to precipitating tanks where the silver is precipitated by copper. The resulting silver assays 999.5 fine, and is sent to the Royal Mint at Ottawa, as well as other mints. The solution from the precipitating tanks is evaporated to the proper density and copper sulphate crystallized out. The gold left in the parting kettles has a fineness of 995.

The refined lead is 99.989 per cent. pure. While a small amount of it is used for the manufacture of lead pipe at Trail, most of the refined metal finds its way to the producers of white lead.

The plant at Trail was the first of its kind on the continent, and

was installed in 1902 with a daily capacity of 50 tons of refined lead. Since that time its capacity has steadily increased, and at present it is producing approximately 100 tons per day. An idea of its output may be gathered from the following statistics: During 1909 the total production of pure lead was 41,883,614 lbs., together with 18,241 ozs. of fine gold, 2,003,003 lbs. fine silver and 51,405 lbs. of copper sulphate recovered from the slimes.[5]

There are no other electrochemical industries in the province at the present time.

Proceeding towards the east, the greatest development in electro-metallurgical and electrochemical industries has occurred in the Province of Ontario.

Calcium Carbide.

The oldest electrochemical industry in Ontario is the manufacture of Calcium Carbide. The Willson Carbide Co., located at Merriton has been in operation since 1897.[6]

"The Company uses as raw materials lime, coke and coal. The lime is obtained from the quarries near Port Colborne, and contains about 92 per cent. of calcium carbonate. The coal and coke are imported from Pennsylvania. The raw materials are first ground in rotary crushers and rolls, and then mixed in the proper proportions and delivered by conveyors and chutes to electric furnaces. The furnaces, slightly conical in shape, are filled gradually, the charges being weighed and fed at stated intervals. [About 100 parts of lime are used to 70 parts of carbon.]

Calcium carbide is formed by the fusion of the raw materials in the electric furnaces. The fusion requires a current of from 2,500 to 3,000 amperes, at a constant pressure of 75 volts. The voltage is regulated automatically by raising or lowering the electrodes. After fusion the furnace is dumped, and the unfused material retreated. The carbide is obtained in the form of a solid fused mass which is crushed and bolted and finally packed into steel receptacles, each containing 100 pounds. There are in all, six electric furnaces in operation, the power for which (1,200 H.P., three-phase) is supplied by three power stations, on the Welland Canal close by. The total yearly capacity is 1,200 tons of carbide." The cost of the power is said to be very low.

The Ottawa Carbide Co., which also utilizes the same process is located on Victoria Island, in that section of Ottawa known as the Chaudiere. The capacity of the plant is 3,000 to 4,000 tons per annum. The electric power is taken from the Ottawa Power Co. The lime, containing 93 to 96 per cent. CaO is derived from Rockland, 38 miles from Ottawa, while the coke used comes entirely from Pennsylvania. The works contain 20 furnaces.[7]

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(5) Report 88, Department of Mines. The Mineral Production of Canada during 1909, p. 27.

(6) Report 24, p. 515.

(7) According to the Report of the Bureau of Mines of Ontario for 1909, each furnace required at that time about 200 H.P. It is hardly likely that the capacity per furnace has remained at this figure during the past decade, as 500 H.P. furnaces are quite usual in the United States.

The annual output of both plants for the period 1905 to 1909 has averaged approximately 2,500 tons.[8]

Ferro Alloys.

The work of Drs. Haanel and Heroult on the electric smelting of iron and steel has had the direct effect of stimulating at least two companies to embark on the manufacture of ferro alloys by the electrothermic process.

After the completion, in 1907, of the Government experiments at Sault Ste. Marie, the Lake Superior Power Co. bought the experimental plant from the Government and used it for the manufacture of ferro-nickel pig from pyrrhotite.[9] At the present time it is utilizing the furnace to produce ferro-silicon for its own consumption.[10]

The other company which is engaged in the manufacture of ferro-silicon is the Electro-Metals Co., at Welland. The company owns about 40 acres of land to the south of the town, on the east side of the Welland Canal. The iron ore is imported from the United States, and silica in the form of rock or flint is brought from Frontenac or Parry Sound district.[11] The Company has four furnaces of from 1,000 to 1,500 H.P. each, the daily production being 5 to 8 tons. The power is obtained from the Ontario Power Co.

Cyanamide, Graphite and Silicon Carbide.

The low cost of power on this side of the Niagara River has led to the establishment of three industries, in each of which power consumption is the chief item of cost.

The **American Cyanamide Company,** located near Niagara Falls, Ont., manufactures calcium cyanamide by the process of Frank and Caro. Nitrogen is passed over heated calcium carbide in closed retorts. The result is the formation of a substance having the formula $CaCN_2$ and known as cyanamide. Investigations at numerous agricultural stations have shown that it can be successfully used as a fertilizer, and the whole of the product manufactured at Niagara Falls is at the present time finding a market in the United States. The cyanamide is not sold as such, but is previously mixed with Chili saltpeter.

The nitrogen for the process is obtained by passing air over heated copper, which is subsequently regenerated by natural gas. The power is obtained from the Ontario Power Co. The Cyanamide Company commenced operations in January, 1910, with a 10,000 ton plant. This is at present producing to its full capacity.

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(8) Report 88, p. 242.

(9) Report 16, Experiments made at Sault Ste Marie, under Government auspices, in the smelting of Canadian ores by electro-thermic process. Final Report on —— by Eugene Haanel, Ph.D., 1907. Pring, some Electrochemical Centres, pp. 73-4.

(10) Report 88, p. 68.

(11) Ontario Bureau of Mines, 1910, p. 30.

The **International Acheson Graphite Co.,** has also established a small plant in the same locality. Its output in 1909 was 513,436 lbs.[12] Incidentally it may be mentioned that both Ontario and Quebec have large deposits of natural graphite. In 1909 the exports from mills in the two provinces amounted to 2,000,000 lbs., valued at $53,302.

The **Norton Company of Niagara Falls, N. Y.,** has a plant at Chippawa for the manufacture of **crystolon.** The latter is a trade name for carbide of silicon. The electric furnace used is probably of the same type as that used for the manufacture of carborundum. A core of coke is surrounded by a charge containing a mixture of sand, coke and sawdust, the latter being added to make the charge porous and thus facilitate the escape of carbon monoxide gas. The current passing through the coke heats up the surrounding charge to a temperature at which the coke and silica react to form SiC, silicon carbide or carborundum. The raw materials used are two different grades of coke (a metallurgical coke with 92% or more fixed carbon and 5% ash, and a petroleum coke, containing about 91% fixed carbon with less than 1% ash), a very pure silica sand, and sawdust. Two grades of product are manufactured, green and steel grey. The power is derived from the Ontario Power Co., and amounts at present to 2,000 H.P., which is received at 12,000 volts and transformed to 145 volts, after which it passes through induction regulators which buck or boost the voltage to 70 and 215.

The whole of the production, which amounts to over 5 tons per day, is shipped to the company's main works at Worcester, Massachusetts, where it is manufactured into different abrasive articles. (For this information I am indebted to Mr. L. E. Saunders of the above company).

Electrolytic Alkali.

An electrolytic alkali industry was attempted about twelve years ago by the Lake Superior Power Co.[13] Among the many subsidiary organizations initiated by this company was the Canadian Electrochemical Co., for the electrolytic manufacture of caustic soda and bleaching powder. One hundred and twenty cells of the Rhodin mercury type were installed, each cell utilizing 1,000 amperes at 5.5 volts. The total capacity of the plant was 4.5 tons of caustic and 9 tons of bleaching powder per day. The salt was obtained from wells in the County of Huron. This plant has, however, been out of commission for a number of years.

At the present time the Canadian Salt Co., of Windsor, Ont., is erecting a plant at Sandwich for the manufacture of caustic soda electrolytically. It is expected that this plant will begin operations very shortly.

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(12) Report 88, p. 197.
(13) Ontario Bureau of Mines, Report for 1901, pp. 61-8. Pring, pp. 48-50.

The Electrolytic Refining Plant and the Ottawa Mint.

The electrolytic refining plant at the Royal Mint, Ottawa, is a recent electrochemical development in this country. For the description of this plant I am indebted to the kindness of Dr. James Bonar, Deputy Master of the Mint.

The gold bullion (after being assayed) is melted with silver in such proportion as to form an alloy containing 40% gold, 56% silver, and 4% base metals. This alloy is cast into anode plates approximately 15 inches long, 3 inches wide, and 3/8 inch thick. Forty-four of these anodes are suspended in a tank containing dilute solution of silver nitrate and a little nitric acid, and the silver deposited out on pure silver cathodes suspended at a distance of 2½ inches from the anodes. When nearly all the silver is removed, a spongy mass of gold is left retaining the original shape of the anode plate. This is removed, washed with hot water, melted and cast into wedge shaped plates 8 inches long, 3½ inches wide, ½ inch thick at the top tapering to ¼ inch at the bottom. The anodes containing approximately 96% gold are then refined further by the Wholwill electrolytic method, a solution of gold chloride and hydrochoric acid being used as electrolyte and strips of pure gold 2½ inches wide, 10 inches long, and 15–1,000 ths of an inch thick as cathodes. The deposited gold is 99.90 to 99.95% fine and is melted into ingots of about 500 ozs.

The power for the deposition is obtained from a direct coupled motor and generator which is capable of supplying 225 amperes at 30 volts when the two windings are in series, and 450 amperes at 15 volts when in multiple. When fully equipped the refinery will have 10 silver and 10 gold cells producing (with ordinary working hours), 20,000 ozs. of fine gold a month. At the present time the output is somewhat less than half that amount. Most of the gold treated in the refinery naturally comes from the Yukon.

Electrochemical Industries in the Province of Quebec.

Most of the electrochemical industries of Quebec are situated around Shawinigan Falls. This falls is situated about 85 miles east of Montreal on the St. Maurice River. A fall of about 150 feet in the waters of this river has been utilized by the Shawinigan Falls Power Co. to develop about 25,000 H.P., most of which is transmitted to Montreal by an aluminum line at 50,000 volts.[14] The town of Shawinigan Falls has been laid out with a view to the erection of a model manufacturing town, and it is therefore only natural that such a point should be chosen for the location of electrochemical industries.

The Northern Aluminum Co., a branch of the Aluminum Co., of America, was the first industry to establish itself at Shawinigan Falls. Owing to the necessity of using direct current at low voltage, "It was considered better to generate the power as direct current.

(14) Montreal Electrical Handbook, p. 121. Pring, p. 40.

The company therefore take their supply of water from one of the penstocks leading from the canal of the Shawinigan Water and Power Co., and are expected to take the capacity of another penstock."[15] The plant covers an area of about 10 acres. The process used is the well knownelectrolytic process of Chas. M. Hall. Alumina (Al_2O_3) dissolved in a molten mixture of the fluorides of aluminum and sodium (or potassium) is electrolysed in a cell consisting of an iron trough lined with carbon, which serves as cathode. The anode is composed of a large number of carbon rods dipping into the charge. The current passing through the fluorides fuses them, and decomposes the alumina, depositing aluminum on the bottom of the cell and liberating oxygen at the anode. Fresh alumina is added from time to time to make up for the amount decomposed. The alumina is prepared from bauxite in the East St. Louis (Ill.) plant of the parent company. "There are 340 cells in operation, each producing, on an average, 150 lbs. of aluminum, 99.4% fine, per day."[16] The total capacity of the works is 25 tons of aluminum per day, about 500 men being employed when the plant is running at full capacity. The output in 1909 was over 3,100 tons.[17]

The plant of the Shawinigan Carbide Co., is situated at a distance of two miles from the power house of the Shawinigan Water and Power Co. The electric furnaces are continuous; the manufactured carbide is drawn off in pots, and the fused mass, after cooling is broken up and granulated in mills. Eight furnaces have been installed, two of which require each 1,500 H.P., and the remaining six require each 750 H.P. for their operation. The combined capacity of the furnaces is 25 tons of carbide per day, requiring a total of 7,500 H.P. About 100 men are employed.

Besides these two plants at Shawinigan Falls, the Electro-Reduction Co., of Buckingham, manufacturers phosphorous and ferro-phosphorus from apatite. No details are available as to the nature of the plant.

(15) Handbook, p. 137.
(16) Report 24, p. 424-5.
(17) Report 88, p. 133.

[NOTE.—The second part of this paper will deal with a review of Canada's mineral resources and the adaptation of electrochemical methods for their exploitation, and will appear in an early issue of this journal.—Ed.]

D. D. McAlpine, '09, is in electrical work at Kakabeka Falls, Ont.

A. G. McLeish, '11, is in the employ of the Mond Nickel Co., Victoria Mines.

J. McNiven, '10, is with the Dominion Bridge Co. in their Winnipeg office.

A. B. Manson, '09, is divisional engineer for the Canadian Northern Railway at Biscotasing, Ontario.

F. H. Moody, '08, is managing editor of the Railway and Marine World, Toronto.

TORONTO MEETING OF THE AMERICAN ELECTRO-CHEMICAL SOCIETY.

The twentieth general meeting of this society was held at the University of Toronto from Sept. 21st to 23rd. There were three professional sessions held for the reading and discussion of papers. All were well attended and many instructive papers were presented. Dr. W. R. Whitney presided at the session.

"The Recent Progress in Electrochemical Iron Smelting in Sweden" was the subject of a paper read by Mr. T. D. Robertson, of the Canadian Böv.ng Co., of this city. It may be summed up as follows:

1. Electric smelting of iron ores is no longer in the experimental stage, but in Sweden is thoroughly established on a commercial scale.

2. The smooth and regular working of the furnace at Trollhattan has been a marked feature, probably less trouble being experienced than would have been the case with a blast furnace doing similar work.

3. The quality of iron produced for steel-making purposes has been shown to be equal, and n some cases superior to that of Swedish blast furnace pig iron.

4. The comparative costs of electric and blast furnace smelting depend in general on the cost of suitable fuel and electrical energy, as the electric furnace simply substitutes one electrical h.p. year for two metric tons of blast furnace fuel. In Sweden there is no doubt that the electric furnace has come to stay on account of cheaper production.

5. The electric furnace is specially adapted to the smelting of finely divided ores or concentrates.

6. Electric smelting in Sweden has a national value as its adoption will result in the development of water powers which could not in many cases be profitably utilized for any other purpose.

Mr. F. A. J. Fitzgerald, of Niagara Falls, N.Y., presented a paper dealing with an unsuccessful furnace experiment, which proved very interesting. In the discussion which followed Dr. Whitney emphasized that the description of unsuccessful experiments should be encouraged for the valuable lessons which they teach.

"Titanium in Iron and Steel" was the subject of a paper by Mr. C. V. Slocum of the Titanium Alloy Manufacturing Co. of Pittsburg, Pa.

Other papers presented were:—

"Production of Molybdenium Steel in the Electric Arc."

"Niagara Transforming Stations."

"Design of a 30-ton Electric Induction Furnace."

"Addition Agents in Electrolytic Copper Deposition for Solutions containing Arsenic."

"Conductivity of Mixtures of Copper Sulphate and Sulphuric Acid."

"Transformation of Other Forms of Carbon and Graphite."

"Electric Laboratory Furnace with Resistor of Ductile Tungsten or Molybdenium."

"Electric Properties of Sodium, Potassium, and their Alloys."

"Electric Resistivity of Iron Alloys."

"Metallic Cerium."

"Thermal Conductivity and Convexion in Gases and High Temperatures."

"Measurement of Small Gas Pressures."

"The Electrochemical Industries of Norway."

"Electric Nickel Smelting."

"Galvanizing Wire in Zinc Dust."

"Electrochemical and Electrometallurgical Developments in Canada," which appears in this issue of Applied Science.

All papers, although decidedly technical, were extremely interesting and represented a great volume of work and investigation. Lively discussion followed each paper, and many points were brought up which otherwise might have been passed over.

Mr. J. B. Gibson, of the Ontario Bureau of Mines, gave a very interesting talk on the mineral resources of the Province of Ontario.

With the aid of a map the author sketched the situation and geology of the different portions of Ontario, and gave an account of the mineral resources which have been found or may be expected to be found in these different portions. In Eastern Ontario there is a great variety of ores, but Northern Ontario is the real home of the metallic deposits.

Mr. Gibson discussed at some length the production of silver, nickel, and gold in Ontario. There have been two eras of silver production in Ontario; the present one began with the opening of the Cobalt mines in 1904.

The nickel industry depends on the nickel-copper ores in the Sudbury district.

The gold industry is at present widely scattered, and while it is not yet very successful, it may be expected to become of great importance in the future.

Mr. Gibson concluded by suggesting two problems of importance which might be solved by electrochemical means. The first had to do with corundum, which is practically pure alumina, and is used at present mainly as an abrasive. But it is a richer ore of aluminum than bauxite, and a process of making aluminum from corundum would be very profitable.

The second problem is the possible recovery of potash. There are deposits of feldspar in Ontario containing 13 to 14 per cent. of potash. If the potash could be gotten out of it we would be able to get independent of Germany, which has at present the monopoly in potash salts.

In the discussion Dr. Whitney remarked that another problem which might be worked out profitably is a process for the complex cobalt silver ores.

APPLIED SCIENCE

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EDITORIAL

VOLUME FIVE NUMBER ONE

Volume V. of Applied Science begins with this issue. In the twenty-fifth appearance among the graduates of the monthly journal into which the Engineering Society saw fit to mould the old Transactions, it is only necessary to repeat that by keeping the graduates in closer touch with the institution, Applied Science has performed the important function for which it was intended. Our aim is to preserve and to further promote this duty, to expand and develop, so as to keep pace with the expansion and development of field among the increasing number of graduates and among Canadians engineers generally.

It is true that an engineer's professional work often leaves him little time for devoting attention to the many things which would give him pleasure. Chief among these is his interest in his Alma Mater. The absorbing tendency of modern business obligates him to over-

look this duty at times, unwillingly though it may be. Therein lies the danger of the graduate losing interest in the university.

APPLIED SCIENCE will co-operate with graduates of the Faculty of Applied Science in any endeavour they will make to strengthen the ties that tend to sever. The Engineering Alumni, the S.P.S. Club in Northern Ontario, the U. of T. Club of New York, and the U. of T. Club of Pittsburg have all done a vast amount of good work in this respect. But it has been of a local nature and has not the far-reaching advantages of this publication. Its appearance monthly, containing papers of interest and instruction, as well as news of the progress of the University in general and the Engineering Society in particular, together with its wide circulation throughout Canada, makes it most suitable for this work.

We want to keep in communication with all graduates; to receive from them news of their professional achievements, papers for publication of improved methods of manufacture, types of construction, results of investigation, and general engineering items of interest to "School" men of the past and present. We also want the graduates to consider our advertisers when in the market for their products. They have the materials to suit your needs. Their reliability is unquestionable. By patronizing them you are materially aiding APPLIED SCIENCE.

Finally, we wish to express our appreciation to a number who have remitted one dollar in advance of the appearance of the first number of this volume in payment of their subscription. Subscriptions are now due. A stock of special binders to hold the six issues are being prepared, and will be furnished free to paid subscribers. The advantage of having one of these binders to preserve your copies as they appear is obvious. It will likewise minimize the call a few years hence for back numbers for incomplete volumes. We regret that we are now unable to supply several back numbers, but look to these binders to lessen the number of requests for them in future. Readers may well consult their own convenience in this matter.

TO FIRST YEAR MEN

First, to the class of 1915, we would tender a reminder of the address given by President Falconer at the opening of the college term. Its beginning marked an epoch in your life's work. You may consider it a serious matter, or, possibly, some may think lightly of it. Your academic course has been completely mapped out for you, and you will find it advantageous to adhere to it as closely as possible. It will take up the greater part of your time, but no more of it than is necessary for the completion of the year's work. The curriculum was not compiled with the intent that you should devote your entire time to study.

There are enough activities in the University of Toronto to keep everyone busy. It is to your own interest to consider again the advice given you as to securing the full value there is in a college course.

The paper presented by Mr. E. H. Darling, '98, at a recent meet-

ing of the Engineering Society, is one of much value to the undergraduate. It displays a number of points not previously thought of by them as entering into the design and construction of this type of building. The "stand for ages" idea is not so important as the quality of adaptability to alterations, in the problem of real efficiency when applied to them; this is one of the many points which scientific study of industrial requirements lays bare.

ARTICLES IN THIS ISSUE

Such a treatment of the subject as has been given it by Mr. Darling, is invaluable to engineers and manufacturers among our graduates, to whom these problems frequently appear in concrete form. The problems of utility, location, and finance have confronted them in building construction, and they are doubtless ready to endorse the qualifications required in the Industrial Engineer and the definition of his work as set down in this paper.

The phenomenal growth in the variety and extent of the industries of Canada during the past quarter century surpasses by a wide margin that recorded in the history of any other country. The progress in city and railway building, in land and mine development, is so largely in the fore at this period that the older established industries are many of them lacking the publicity previously bestowed upon them.

One of the newer industries of the country is aptly described in Dr. Dushman's paper, dealing with the application of electrochemistry and electro-metallurgy. As has been the rule in Canadian progress, the introduction of the methods therein discussed is in keeping with the growing need of caution against wasteful tactics in the treatment of minerals and in the utilization of bye-products. The electrolytic refinement of the rarer metals, the manufacture of calcium carbide, ferro nickel, ferrosilicon, graphite, carborundum, cynamide, caustic soda, ferrophosphorus and aluminum, are among the new branches that are offshoots of the scientific investigation of the agency of electricity in effecting chemical change. It suffices to say that the list, although not lengthy as yet, shows that the industry is on a firm basis in Canada, which is proven by statistics relating to the output of the concerns already established. Owing to the wide field, great progress will be made as the applications increase in number and broaden in extent.

In this number, a paper appears, dealing with the installation of a central heating, lighting, ventilating and power service for the whole group of buildings comprising the University of Toronto. The construction of this system has been in progress since May, 1910, and the knowledge of its completion, with the return of lawns and walks to their normal state, is very gratifying. The excavation of some 295,000 cubic feet of earth for the construction of 5,875 feet of tunnel gave the grounds an unsightly appearance for a considerable length of time. An idea of the

magnitude of the undertaking of which this tunneling formed a part is clearly given in the article and the illustrations which accompany it. This plant will effect a great economy in the heating and lighting of the University buildings. Hitherto in each of the college buildings there has been a heating outfit and this, of course, involved the maintenance of one or two men in connection with each. Several of these plants had been in commission for a great length of time, and they were not giving the greatest efficiency. For these reasons, together with the fact that so many new buildings have been erected recently, and that more will be constructed as the University grows, the authorities have deemed it advisable to install this most modern and complete heating and lighting plant.

ADDRESSES UNKNOWN.

An effort is made to keep on file the latest addresses of all the graduates. The mutual advantages of a complete list is obvious. Those who can assist us by giving information regarding the whereabouts of any of the following men will confer a great favor by so doing:—

J. R. Allen, '92; A. G. Anderson, '92; A. P. Augustine, '07. C. B. Aylesworth, '05; H. P. Barker, '93; H. E. Beatty, '04; M. B; Bonnell, '04; W. M. Brodie, '95; D. B. Brown, '88; J. M. Brown, '02; J. A. Brown, '07; W. J. Bruce, '07; R. J. Burley, '04; A. R. Campbell, '02; B. Carrey, '99; J. Clark, '00; G. A. Clothier, '99; P. C. Coates, '04; F. T. Conlon, '02; F. Dowling, '05; H. P. Elliott, '96; J. C. Elliott, '99; W. E. Foreman, '99; R. E. George, '03; A. C. Goodwin, '02; J. B. Goodwin, '92; W. A. Gourlay, '03; W. H. Greene, '09; R. C. Harris, '06; E. E. Henderson, '85; J. A. Horton, '03; H. S. Hull, '95; D. Jeffrey, '82; J. C. Johnston, '00; G. S. Jones, '05; W. C. Kirkland, '84; J. E. Lavrock, '98; A. E. Lott, '87; F. R. MacDonald, '08; J. M. MacInnes, '06; J. T. MacKay, '02; J. A. MacKenzie, '06; W. D. MacKenzie, '07; C. McCuaig, '04; G. G. McEwen, '04; D. W. McKenzie, '05; J. V. McNab, '06; F. W. McNaughton, '98; F. W. McNeill, '07; A. L. McTaggart, '94; F. Martin, '87; C. A. Maus, '03; R. S. Mennie, '02; W. Mines, '93; E. E. Moore, '04; R. W. Morley, '04; D. G. Munro, '07; J. D. Murray, '07; G. Pace, '04; J. D. Pace, '03; J. Paris, '04; H. A. Ricker, '08; H. D. Robertson, '02; W. A. Robinson, '08; J. O. Roddick, '06; A. E. Shipley, '98; R. W. Smiley, '97; S. E. Thomson, '04; E. A. Weldon, '97; A. F. Wilson, '07; J. N. Wilson, '06.

BOOK REVIEWS.

(We publish below a review of two books of which Mr. H. G. Tyrrell, a graduate of 1886, is the author, and in the case of the first, the publisher as well. Mr. Tyrrell's wide experience as a structural engineer fits him for such a task as the publication

of these books imply. We hope to have him favor us with an address to the Engineering Society at some time during the year.)

History of Bridge Engineering. Henry Gratton Tyrrell, C.E.; published by the author, Chicago; 447 pages, 6x9, fully illustrated.

As pointed out in the preface, proficiency in any art is not attained until its history is known. Many students and designers have found, after weary hours of thought, that the problem before them was considered and perhaps mastered by others years ago.

Mr. Tyrrell has undertaken a stupendous task, as anyone who is at all familiar with the history of bridge building can readily attest. In view of this very fact, it is acknowledged by the writer that a great deal of information was necessarily crowded out of a volume of this size; but the final result is such that a very complete work has been gotten together. In the evolving of new work the designer does well to be familiar with outlines and details of other and perhaps older work. This book can very well help in giving such ideas to the designer.

Quite necessarily a good deal of space has been devoted to bridges built before the advent of metal as a structural material. Although professedly not of a technical nature, this book has distributed throughout its pages a large amount of dimensions that are valuable when taken in conjunction with the illustrations.

Altogether, the book is a credit to the author and will be a valuable addition to engineering literature.

Design and Construction of Mill Buildings. Henry Gratton Tyrrell, C.E.; published by the Myron C. Clark Publishing Co., Chicago and New York; 490 pp.; 6x9, fully illustrated; price $4.

Mill building construction is becoming an extensive branch of engineering in itself, and this book is a decided addition to the available literature on the subject. This book is the outcome of a smaller one entitled "Mill Building Construction," published in 1900. These books are based on the author's personal experience, and most of their contents are from his notes and records.

The author has included a part on "The Theory of Economic Design," which gives a knowledge of the possibilities and requirements. This has caused some repetition later in the book.

He has devoted a great part of the book to descriptions of the details and materials of construction. The different loads which may come on a structure are well analyzed, and there is a good chapter on framing.

There is a total absence, however, of methods of the theoretic analysis and graphic statics, which the author says have been sacrificed for more important material. His strictures on mathematics and mathematical analyses, in which he quotes Tau-

twine's Engineer's Handbook, might well have been omitted for the book lacks in just that department.

However, the book on the whole is a valuable one to the designer and estimator, containing much of use to both, when used in connection with other treatises on mathematical methods and statics.

THE ENGINEERING SOCIETY.

The University of Toronto Engineering Society held its first meeting of the year on October 18th. Dean Galbraith was the speaker, and gave an account of the history of the institution of which he is the head, since the registration of its first student. The address was exceptionally interesting to junior undergraduates, and was no less heartily received by those who had learned more or less of the "School" in previous years.

Several vacancies upon the executive of the society necessitated a call for candidates. Mr. R. J. Fuller, '11, was chosen by acclamation to succeed Mr. Watts as first vice-president of the society. The elections following other nominations resulted in Mr. R. D. Galbraith being elected to the presidency of the first year and their representative to the executive; while Mr. L. G. Glass was made first year representative to the undergraduates' parliament.

On Wednesday, Nov. 1st, Mr. E. H. Darling, '98, assistant engineer, Hamilton Bridge Works, read a lengthy and instructive paper on the design of manufacturing buildings. Mr. Darling's wide experience in work of this nature showed itself in his manner of dealing with such a complex subject so that students of all years were able to grasp the features under discussion. The paper appears elsewhere in this issue.

Mr. W. B. McPherson, '11, the president of the society for the year 1911-12, was in the chair.

The various sections into which the society is divided have made arrangements with a number of manufacturing establishments for official visits to their factories and plants in operation. Several of these little trips have already been made. On Oct. 19th over one hundred members of the civil section of the society visited the plant of the Canada Foundry Co. in this city, and spent a couple of instructive hours studying the different processes in operation there.

The various methods of manufacture, and the different machines were explained by Professors McGowan and Gillespie, Mr. Young, and other members of the staff.

The bridge department proved of special interest, considerable time being spent viewing the assembling of a bascule truss, and also the manufacture of different sizes of moulds for water pipes.

The wide range open for the inspection by a large party made this expedition a most successful one, and the Canada Foundry Co. are the recipients of high appreciation from the society for their courtesy.

On Oct. 25th about one hundred and fifty men of the third and fourth years, under the direction of Prof. Angus, went to Niagara Falls to inspect several places of interest there. The party first proceeded to the Ontario Power Company, where the intake system, power house and transforming house were visited. The plant of the Canadian Niagara Power Co. was also thoroughly inspected. The turbines here are arranged on a vertical shaft, the head being from 135 to 140 feet, varying with river conditions.

From this plant the party went up to the power house of the Toronto Power Co., where, as at the other two plants, the management were most courteous and obliging and afforded every facility for inspecting the plant. Here the erection of some new wheels was in progress, and it was an excellent opportunity for seeing the different parts of the turbines. Later a visit was also made to their transformer station on the hill.

WHAT THE GRADUATES ARE DOING.

(This department is conducted with double object in view; first, to give the graduates professional news of each other; second, to give the undergraduate readers some idea of the work in which they will be engaged after graduation).

E. T. Austin, '09, is with the Mond Nickel Co., Victoria Mines, Ontario.

H. H. Betts, '06, is in the employ of the Rio de Janeiro Tramway Light & Power Co., Rio de Janeiro, Brazil.

R. H. H. Blackwell, '10, is resident engineer for the C.N.O. at Biscotasing, Ont.

E. R. Birchard, '09, is with the Russell Motor Car Co., West Toronto.

E. T. Cain, '11, is in the employ of the Dominion Bridge Co., Lachine, Que.

A. Cameron, '06, is in the employ of the Vulcan Iron Works, Winnipeg, Man.

A. M. Carroll, '08, is with the Rochester Cobalt Mines, Limited, Cobalt, Ont.

N. L. R. Crosby, '05, is on construction work for the McClintic Marshal Construction Co., Chicago.

E. M. Dann, '09, is in the Railway Lands Branch, Department of the Interior, Ottawa.

G. W. Dickson, '00, is with the Laurentide Paper Co., Grand Mere, P.Q.

V. H. Emery, '10, is assistant manager of the McIntyre Mines, Porcupine, Ont.

R. H. Houston, '06, is with the Vulcan Iron Works, Winnipeg, Man.

A. E. Hunter, '09, is on survey work in the Peace River district.

J. T. Johnston, '08, is assistant engineer in the Trent Canal.

A. E. Lennox, '09, is publicity engineer for the N.E.L.A., Cleveland.

A. G. MacKay, '07, is in the employ of the Hudson & Manhattan Railway Co., New York City.

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